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ABSTRACT

A description and evaluation of a year-long science in-service program for elementary teachers is provided. Consisting of three components, the program was designed to expand teachers' understandings of physics and chemistry concepts and processes and to encourage more science teaching and science activities in their classrooms. The on-campus instructional components involved 90 hours of content instruction, laboratory activities, and acquisition of school district resource information and materials. Two-thirds of this time was devoted to traditional physics and chemistry topics and one-third to interdisciplinary topics such as solar energy, ecology, and science as a human activity. A sample lesson plan for physics and one for chemistry are provided. An off-campus in-service program conducted simultaneously with the on-campus program involved weekly visits to participating teachers to observe them, review and critique materials, and present model demonstrations. The last component, subjective and objective evaluation, consisted of informal classroom observations, a pre- and posttest of science content knowledge, and a Q-sort instrument to assess teacher beliefs about the importance of specific classroom behaviors by teachers. Evaluation results favored the team teaching approach used. (DC)

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AN IN-SERVICE PROGRAM FOR ELEMENTARY TEACHERS: COMPONENTS, INSTRUCTIONAL PROCEDURES, AND EVALUATION

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AN IN-SERVICE SCIENCE PROGRAM FOR ELEMENTARY TEACHERS:

COMPONENTS, INSTRUCTIONAL PROCEDURES, AND EVALUATION

This paper is an overview and analysis of a year long science in-service program for elementary teachers. It describes the components of the program, discusses the implementation of the program, and reports about evaluation procedures that were utilized. The program was in part funded by the National Science Foundation.

This program provided elementary teachers with inservice instruction on the concepts and processes involved in elementary school science. The group participated in lectures, discussions and laboratory activities that were designed to broaden their understandings of physics and chemistry and also to aid in expanding science activities and science teaching in their respective classrooms. Follow up activities at some of the schools also provided additional assistance to teachers who where sometimes reluctant to try new science teaching approaches. There were basically three main parts to the program: (1) an on-campus instructional component, (2) an off-campus in-service component, and (3) an evaluation and continuing education component. All three components were implemented at the same time. The instructional staff consisted of one university chemistry professor, one university physics professor, 2 university elementary science education professors, one local school district science coordinator, and one university graduate assistant. The entire staff was involved in all three components. However, they were assigned more responsibilities in each of their specific areas of expertise. This allowed maximum interaction and input from all those involved.

On-Campus Instructional Component: The on-campus component was designed so that during each session, participants would acquire content knowledge, participate in laboratory activities - some at their level and some that required slight modification to be used at the elementary school level- and acquire information and materials that were available at their school district. Initially, the participants engaged in inquiry laboratory activities after receiving classroom instruction of the concepts and processes being stressed each session. This format was changed later on. The laboratory activities were conducted first and the discussions on chemistry, physics, and interdisciplinary topics came later in the evening. This format appeared to meet the needs of more of the participants. They stressed that they needed to know about simpler experiments that could be done before more complex ones involving some sophisticated equipment were demonstrated. The involved faculty also liked this format since it was a more realistic view of how science experiments are conducted in actuality. Sophisticated science equipment is not developed until problems are analyzed with the available equipment.

The topics discussed during this component included physics and chemistry concepts which formed a basis for the interdisciplinary nature of the physical sciences. Additionally, the fundamental concepts in each of the academic areas were selected for thier direct application to the elementary school science program. Lastly, topics were selected that offered the largest variety of laboratory activities since the activities integrated science concepts with science processes by involving the teachers in "doing" science. The physics topics included: work, energy, heat, optics and light, color, sound, magnetism and electricity, and simple machines. The chemistry topics included: properties of matter, solutions, elements/compounds, physical and chemical change, gases, reaction rates, microscopic structure of matter, and

periodicity. The interdisciplinary topics included: solar energy, nuclear energy, water purification, pollution, ecology, spectroscopy, and science as a human activity. Although this is a quite comprehensive list of science topics, it was possible to cover all the areas due to the year long duration of the program. Overall, ninety hours of on-campus instruction and laboratory experience were completed. Sixty-five instructional hours were devoted exclusively to each science discipline. The remaining twenty-five hours of classroom instruction was devoted to the topics that were general and interdisciplinary.

For the weekly on-campus meetings, the time allocations, specific types of activities, and methods of instruction varied. The following are two examples of the weekly time schedules, objectives, and lesson plans. One illustrated lesson plan is for a chemistry topic and one for a physics topic.

Content Area: Chemistry

Topic: Solutions

Time Schedule Objectives

6:30 - 8:15 (Lecture and Discussion of Solutions)

Objective 1: The program will provide participants with scientific knowledge about characteristics of solutions and properties of solutions.

Specific topics discussed will include the following:

1. Types of Solutions
    a. solid solutions -- alloys, including thermal and electrical properties of solid-solid solutions.
    b. Liquid solutions -- types and properties of solid-liquid and liquid-liquid solutions.
    c. Gaseous solutions -- types and properties of gas-gas solutions.
2. Properties of Solutions

a. Concentrations -- per cent of solute, molar, and molal solutions are defined, illustrated, and discussed.

b. Colligative properties of solutions -- boiling point elevation, freezing point depression, and osmotic properties.

3. Electrolytes

a. Types of electrolytic solutions

b. Strength of electrolytic solutions -- included are definitions and discussions of electrolytic and non-electrolytic solutions.

c. Percent dissociation in solutions.

4. Solubilities

a. Properties of solvents

b. Properties of solutes

c. Temperature effects on solubility

5. Acid-base properties of liquid solutions

8:15 - 9:15 (Laboratory experiments dealing with solutions)

Objective 2: The program will provide participants with knowledge of science concepts through meaningful laboratory experiments (some which are directly applicable at the elementary level) that demonstrate and extend the knowledge outlined in Objective 1.

Objective 3: The program will emphasize to participants that scientific processes are part of the subject matter of chemistry.

The laboratory experiments for this topic are based upon three laboratory teaching methods: 1) guided discovery where groups work individually doing different experiments related to one problem and make discoveries individually or by analyzing group assembled data; 2) proof by scientific method where students do the same pre-determined science experiment to point out a certain scientific fact or to explore some science content

utilizing the scientific method; 3) experimental inquiry where groups use experimental methods to study hypotheses generated by discussion of one science problem or phenomena.

Specifically, Objective 2 and Objective 3 will be met by having the class members break up into small groups and individually pursue one of the following laboratory activities:

1. Determination of thermal and electrical properties of alloys (solid solution)
2. Effects of mixtures of gases on buring time of candles
3. Layering liquids and mixing liquids
4. Determination of boiling point elevations for different concentrations of solutions
5. Laboratory experiments on osmosis
6. Conductivity experiments with electrolytes
7. Affects of temperature on dissolving rate of solids
8. Experiments dealing with acids and bases and indicators
9. Electrical conductivity of acids and bases
10. Titration experiments
11. Determining purity of liquid solutions (filtration)

9:15 - 9:30 (Analysis session)

Objective 4: The program will place emphasis on participants' observations and comments as to the general feasibility of introducing chemistry content and laboratory experiments into their respective classrooms.

This objective will be met by a large group discussion among the project personnel -- chemist, teachers, and science educators.

Content Area: Physics

Topic: Optics and Light

Time Schedule and Objectives:

6:30 - 8:30 (Lecture and Discussion of Optics and Light)

Objective 1: The program will provide participants with scientific knowledge about optics and light and observable phenomena related to propagation of light, reflection, refraction color mixing and spectroscopy.

Specific topics discussed will include the following:

1. The nature of light
    a. continuous spectra
    b. bright line spectra
    c. band spectra
    d. illuminance
    e. velocity of light
    f. general spectroscopy
2. Light reflection
    a. angle of incidence and reflection
    b. mirrors -- concave and convex
3. Light refraction and dispersion
    a. lenses
    b. rainbows
    c. prisms
    d. telescopes and cameras
4. Color
    a. color classification
    b. additive color mixing
    c. subtractive color mixing
    d. colored shadows

8:30 - 9:30 (Laboratory experiments dealing with optics and light)

Objective 2: The program will provide participants with an opportunity to explore the phenomena of light in a laboratory setting using sophisticated equipment as well as equipment that will be available in most elementary school rooms.

Objective 3: The program wil provide participants with the laboratory skills necessary to design, develop and evaluate effective laboratory activities using and providing proper maintenance of appropriate equipment.

The laboratory activities for this topic are based upon a laboratory teaching method of discovery learning where groups work with the same or similar equipment individually to study problems and phenomena of interest to them.

Specifically, Objective 2 and Objective 3 will be met by having the class experimentally pursue questions they may have about the nature and characteristics of light under the guidance of elementary science educators and a University physicist. Light emission sources, lenses, mirrors, optical benches and other complex science equipment will be available for use during these experiments. A learning center approach will be utilized.

Objective 4: The program will assure competence in providing meaningful pupil learning experiences at the elementary level dealing with concepts related to light and optics.

This objective will be met through classroom visitations scheduled by the staff at the participants' respective schools.

Off-Campus In-Service Program: The in-service part of the program was implemented concurrently with the on-campus instructional program. The science education faculty and the science coordinator from the district were the most involved with this component. It basically included weekly visits to the classrooms of the involved teachers. During some of the visits the faculty

observed and video-taped lessons that were developed by the teachers. They also reviewed and critiqued materials such as learning centers and science fair projects that were in the developmental stages. Lastly, they also included the faculty presenting model demonstration lessons to emphasize how the concepts, processes, and laboratory experiments conducted on-campus could be integrated into the elementary classroom. Overall, these visits served three general purposes. First, they offered further instruction in the content area. Second, they checked on the accuracy and effectiveness of the content being introduced to the children. Third, they helped to subjectively assess teachers' and students' attitudes and abilities relative to science instruction.

Evaluation and Continuing Education Component:

The evaluation procedures were both subjective and objective. One of the objectives of the project was to get more teachers in grades 4-6 involved in science instruction in their classrooms. There was subjective observational evidence that this objective was met. From classroom visits it was ascertained that many of the participants were utilizing the suggested demonstrated laboratory activities in their elementary classrooms. Furthermore, many participants brought teacher developed materials to class and shared them with the rest of the group. In this way, other participants could see how the concepts could be taught in their classrooms. Some problems were discussed and the group helped by offering alternative activities and procedures.

Additionally, many of the teachers had their students participate in the Southern Arizona Regional Science Fair. The total number of elementary exhibits at this science fair more than doubled over the preceding year. Many of the projects were more complex and also stressed the processes of science more than the preceding year's projects. The teachers involved in

this program expressed the view that previously they had experienced difficulty in defining and developing adequate projects in their classrooms. After participation in the project, they realized that they were most competent to do this, allowing them to encourage their elementary children to realistically pursue scientific endeavors on a more individual basis. Thus, there was much evidence that through participation in this project teachers were more self-confident about teaching science and the teacher's elementary school children were more self-confident about pursueing independent science projects.

A second objective of this project was to extend the participants' knowledge of the content of physics, chemistry, and interdisciplinary topics. To ascertain whether this objective was met, the participants were pre and post tested on a science content measure. This science content measure was specifically developed for this project and included questions related to the topics discussed throughout the year. On the content measure, there was an increase in the post test scores over those of the pre test scores. However, this increase was not shown to be significant to the 0.0t statistical level. Therefore, although there was evidence that the participants did acquire a greater understanding of the scientific principles discussed, it could not be precisely stated as a definite conclusion. One of the reasons for this possible insignificance was the difficulty level of the developed content test. The items were chosen to test concepts that elementary school children should comprehend. Many of them were parallel to those used on the National Assessment Tests for children this age. Two examples of the test items are:

1. The sun and a penny are alike in which of the following ways?

   a. both weigh the same
   b. both are made of atoms
   c. both are made of metal
   d. both are the same temperature

2. Which of the following tasks would take the most

   a. lifting a ten pound weight one foot

   b. lifting a twenty pound weight one foot

   c. lifting a ten pound weight two feet

   d. lifting a twenty pound weight two feet

A number of the participants got all items correct on both the pre and the post test. This topping out has the effect of lowering the level of significance determined by the statistical test which was employed.

Additionally, the participants completed a Science Teacher's Behavior Q-sort instrument to determine their beliefs about the importance of specific teacher behaviors in the classroom.

Analysis of the Science Teacher Behavior Q-sort instrument data revealed that there were four different types of science teachers in the elementary classrooms. Descriptions of these science teacher types are reported in the document ERIC ED 184 889.

Along with the information gained from this Q-sort factor analysis, it was also determined that the groups of teachers identified achieved differentially from the project. Since this project stressed processes of scienc- as well as content of science, these groups of teachers apparently viewed the demonstrated laboratory and lectures with differing criteria. Thus, the usefulness of the activities demonstrated was more apparent to the differing groups of teachers. It appears that for a program similar to the one described, teacher selection procedures employing the Science Teacher Behavior Q-sort instrument could provide a sample of teachers that are more likely to benefit overall from such a year long involvement with scientists and science educators.

Credit for part of the success of this program must be given to the

number of faculty involved. Overall, there were two university elementary level science educators, one univestiy physicist, one university level chemist, one school district science consultant, and three graduate assistants present at all the meetings. Some of the graduate assistants were supplied by the science departments of The University of Arizona. The fact that there were so many involved personnel allowed interactions among educators with sometimes varying viewpoints of science education. It also allowed the sixty-four selected participants to interact on a personal level during the laboratory activities. Thus, while the participarts could get individual help during the inquiry oriented laboratory excercises, they also were able to interact with a larger numer of fellow elementary teachers during the large group lectures and discussion sessions. From the experiences of this program it appears that programs utilizing a team teaching approach among scientists and science educators and having a large number of participants may be highly successful. The larger number of participants allows for more interaction among peers and also keeps the overall cost per participant hour down. It was felt by all that a program format of one instructor, one laboratory assistant and thirty or fewer participants would not have been as successful.